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MINING AND GRINDING METHODS AND COSTS AT THE CLAYCRAFT COMPANY SHALE PIT, TAYLOR STATION, COLUMBUS, OHIO

BY

E. J. LINTNER

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MINING AND GRINDING METHODS AND COSTS AT THE CLAYCRAFT COMPANY SHALE PIT, TAYLOR STATION, COLUMBUS, OHIO[1]

By E. J. Lintner[2]

INTRODUCTION

This paper is one of a series being prepared by the United States Bureau of Mines describing clay and shale mining and crushing methods and costs at various operations throughout the United States. These papers are designed to disseminate technical information regarding methods used. The cost tabulations represent local operating expenditures only and not total production costs. It is recognized that publication of total production costs may, in many instances, cause embarrassment to the individual operator as well as to the industry as a whole. On the other hand, it is essential to the technical discussion and study of methods employed to consider operating costs. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulations shall ensue.

The open-pit recovery of clay and shale is a comparatively simple operation in comparison with underground mining; nevertheless, it represents an appreciable factor in the cost of manufacture.

The following report deals specifically with the methods employed by the Claycraft Company, which operates one of three shale planers found in Ohio.

The author wishes to acknowledge the assistance of the following persons: C. Forrest Tefft, general manager; H. L. Dutro, sales engineer; and R. F. Boss, plant superintendent.

HISTORY

The first clay operation in this area was at Summit, 8 miles east of the Columbus city limits, about 1890. This was known as the Columbus Clay Manufacturing Co. Here drain tile, building tile, and face brick were

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2/ Associate mining engineer, U.S. Bureau of Mines.

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manufactured from the surface clays. A little later, this company opened a small pit in the Bedford shale near Taylor Station. The shale was shipped by rail approximately 5 miles to their plant at Summit. Here it was mixed with surface clays. Still later, the superiority of the Bedford shales having been definitely established, the plant was moved to Taylor Station.

About 1905, the Columbus Contractors' Supply Co. was organized. In their open pit, a 3/4-cubic yard steam shovel was used to load the material into 1-1/2-cubic yard cars. The cars were then pulled out of the pit by means of a steam hoist and dumped into a bin directly over the dry pans.

In 1919, the Franklin Brick & Tile Co. acquired this plant and properties. A new and modern plant, containing a continuous gas-fired tunnel kiln, was erected adjoining the old plant.

In 1925, the Claycraft Co. of Columbus, Ohio, purchased these plants and properties at a receiver's sale. Approximately $200,000 was spent in remodeling and enlarging the plants.

The old plant is now known as Plant no. 4 and produces face brick and building tile. The newer plant is known as Plant no. 5. This unit produces glazed brick made from clay shipped from the company's mine at Shawnee, Ohio, where Plants no. 1 and no. 2 also are located. At these two latter plants, buff and gray face brick are manufactured. Plant no. 3 is located just north of the Ohio State fair grounds in Columbus.

Location

The Taylor Station plants are approximately 3 miles from the east city limits of Columbus, Ohio, just north of State Route 16 (fig. 1). It is served by the main line of the Pennsylvania Railroad.

GEOLOGY

The material mined here is termed the Bedford shale of the Mississippian system. It outcrops in a rather narrow strip along the eastern border of the Ohio shales, the dark red color making it conspicuous. "The Bedford shale is usually an argillaceous deposit varying in color from bluish gray to a red or chocolate brown, the red color usually being confined to the middle portion."3/ In a freshly exposed section, the layers of shale appear massive but soon weather into a sticky red clay. An excellent example of this formation existing in a weathered condition is found just east of Central College in Blendon Township.

3/ Stauffer, Clinton R., Hubbard, Geo. D., and Bownocker, J. A., Geology of the Columbus Quadrangle, 1911; Geological Survey of Ohio, vol. 14, p. 28.

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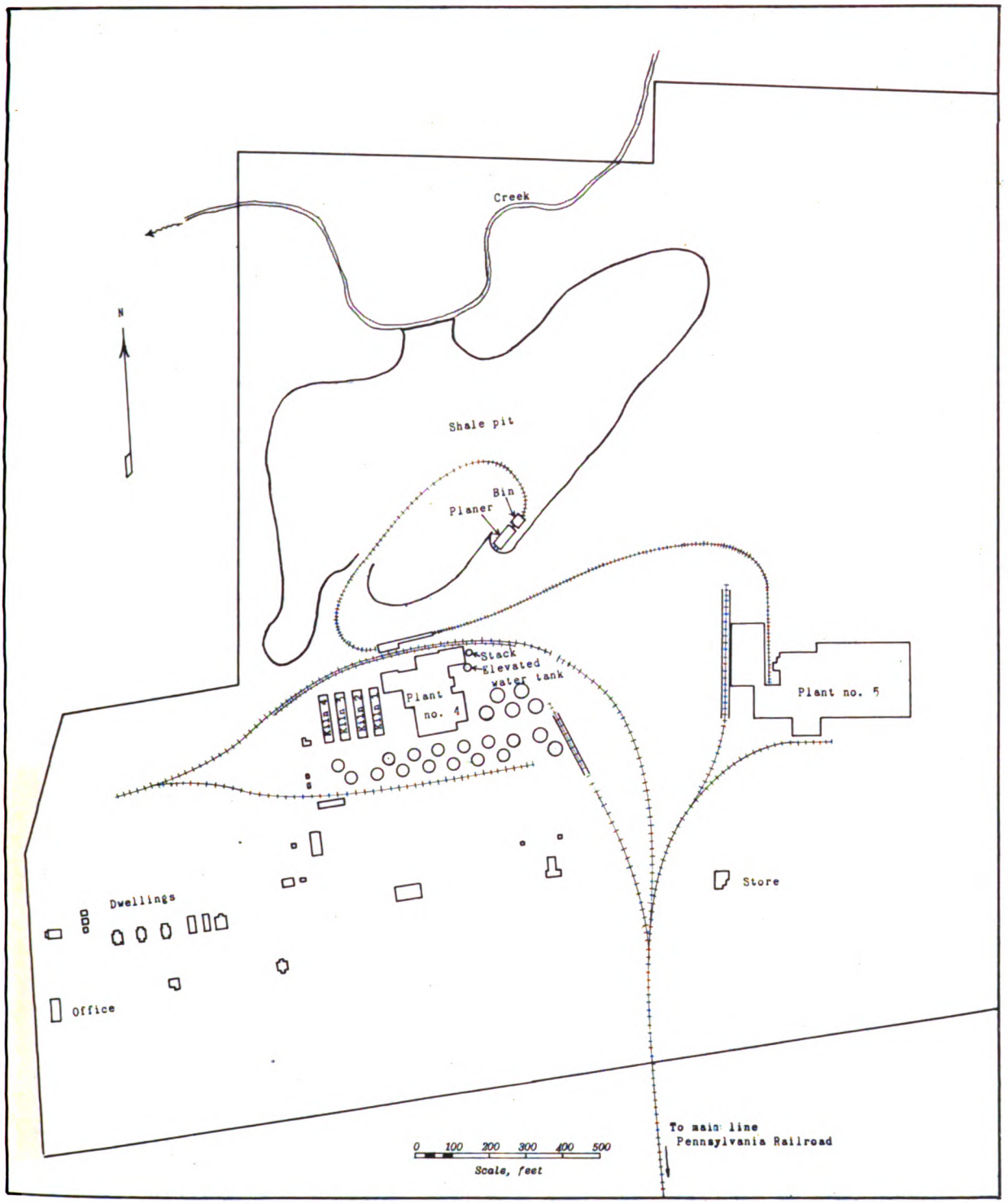

Figure 1.- Property map, Taylor Station, Claycraft Co.

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Here the Bedford shale forms a line of bluffs along the east bank of Big Walnut Creek, where the soft and easily eroded shale has assumed a most striking topography, resembling to a limited extent that of the "Bad Lands" of the West. The color of the central portion of the formation is so conspicuous here as to have fastened the name "Red Hills" upon this locality.4/

A vertical section taken east of Gahanna, approximately 2 miles north of Taylor Station, was as follows:5/

Soft argillaceous blue shales, becoming arenaceous toward the top. Some of the slablike fragments, when freshly exposed, show marks resembling the impressions of plant stems	38'-8"
Soft argillaceous gray mottled shales	8'-0"
Soft fissile red to chocolate brown shale. These layers weather rapidly into a stiff clay	25'-6"
Soft argillaceous blue shale, quite fissile and much jointed	15'-6"
Argillaceous blue shale, very fossiliferous, and especially so near the base	2'-0"
Dark bluish brown rather soft shale, containing fossil shells and norm trails (?), the latter cast in iron pyrites	0'-4"

A section exposed by the planer in the Claycraft pit is as follows:

Overburden	6'-0"
Reddish brown shales	18'-0"
Bluish gray shales	6'-0"

From this exposed section it is plainly evident that glacial action has removed the top blue and gray shales. To the northeast, however, the deposit increases in thickness, and is capped by the Berea sandstone.

A characteristic analysis of the Bedford shale is as follows:

	Percent
Silica, SiO_2	59.63
Alumina, Al_2O_3	18.33
Titanic oxide, TiO_2	1.09
Ferric oxide, FeO_3	6.49
Phosphorus pentoxide, P_2O_5	.06
Lime, CaO	.98
Magnesia, MgO	1.04
Potassium oxide, K_2O	3.07
Sodium oxide, Na_2O	1.58
Moisture at 105° C.	1.62
Ignition loss	6.07

4/ Stauffer, Clinton R., Hubbard, Geo. D., and Bownocker, J. A., Geology of the Columbus Quadrangle, 1911: Geol. Survey Ohio, vol. 14, p. 28.

5/ Stauffer, Clinton R., Hubbard, Geo. D., and Bownocker, J. A., Geology of the Columbus Quadrangle, 1911: Geol. Survey Ohio, vol. 14, p. 30.

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Since the beginning, various types of brick, drain, and partition tile have been manufactured in this field.

> In this locality, the Bedford shales are covered with from 6 to 8 feet of glacial drift, composed of a very good quality of clay. It is compact, fine-grained, and yellowish-brown in color. It contains a considerable number of limestone boulders, and also a finely divided limestone derived by mechanical wear from these boulders.6/

This fact limits its use in the making of brick at the present time.

The surrounding country is fairly level and traversed by streams flowing in a southerly direction into the Scioto River. At various places these streams have cut through the strata and exposed the successive formations both above and below the Bedford shale. The deposits dip slightly to the east, the strike being northeast.

MINING METHODS

Stripping

Stripping is done with a gasoline caterpillar, full-circle shovel having a 1-cubic yard dipper. The overburden is loaded into a hopper directly over one end of a 24-inch by 30-foot belt conveyor on a cantilever frame overhanging the shale face, by which it is deposited on the floor of the open pit (fig. 2). A 30-H.P. motor drives this conveyor at a speed of 50 feet per minute. The hopper holds approximately 2 cubic yards of material. The conveyor unit is mounted on a skid and is pulled forward by the shovel. This arrangement requires only one handling operation in order to dispose of the overburden entirely.

A strip approximately 50 feet wide and of such length as will run the planer for about 1 to 4 weeks (fig. 3) is cleared. No larger area than this is stripped for fear of caving and the washing of overburden onto the exposed surface of the shales. By exposing only a comparatively small area of shale, sloughing along the top edge of the shale face is kept to the minimum. Excessive sloughing and caving will delay the planer operation seriously. The floor must be kept clean, so that the planer can move over it, as it must be possible for the machine to keep close to the face at all times. Should any material slough off the face and fall onto the machine, it would have to be removed by hand, causing serious delay and increased cost.

In a short time, the length of the movable conveyor will be increased to 40 feet. This is necessary in order to place all of the overburden entirely beyond the open edge of the working face, which insures maximum recovery of shale without any possible contamination of waste material.

6/ Westgate, Lewis G., Geology of Delaware County: Geol. Survey Ohio, Bull. 30, 1926, p. 89.

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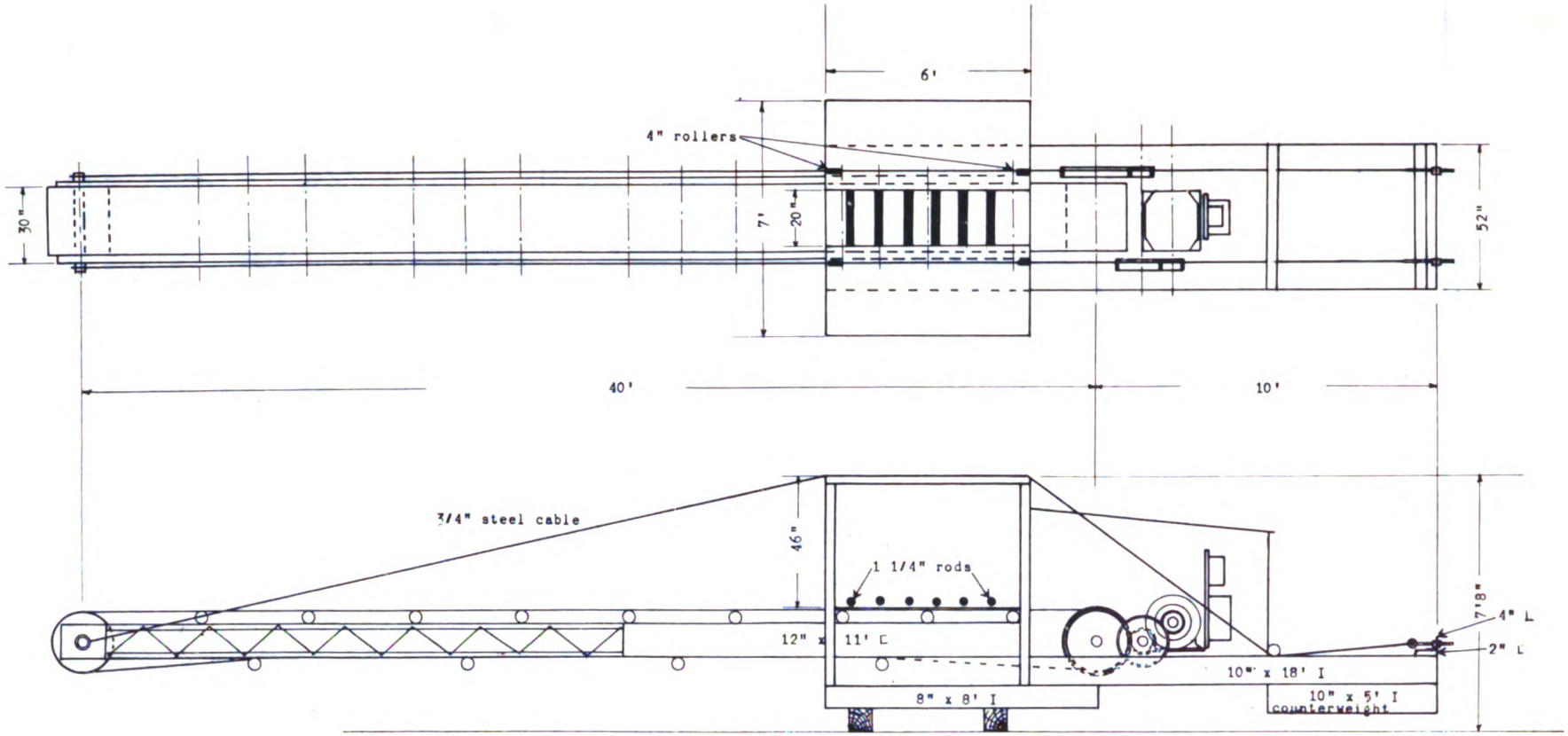

30-hp. motor
Conveyor belt, 24" x 30'
Pulleys, 21" diameter

Figure 2.- Sketch of stripping conveyor.

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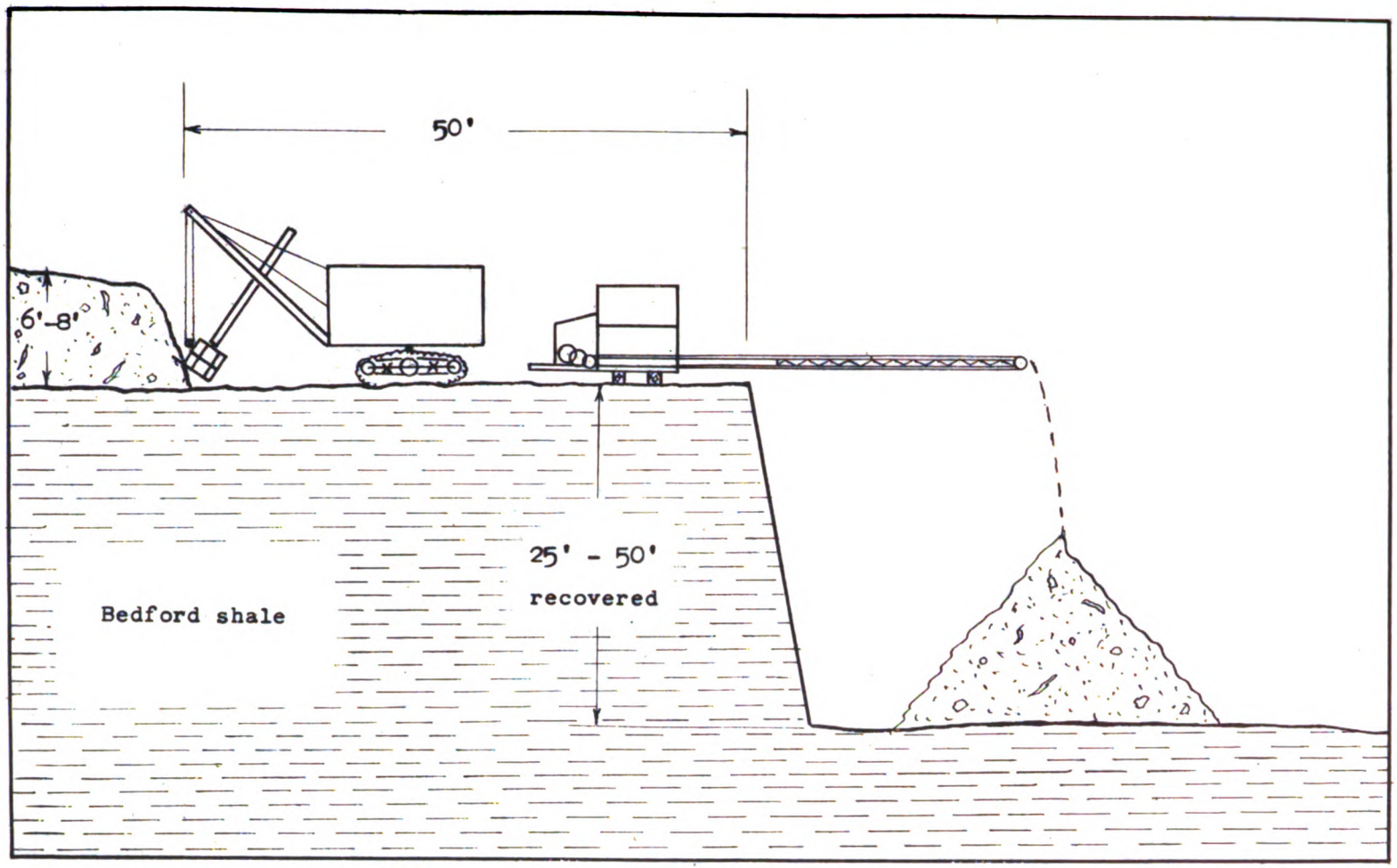

Figure 3.- Sketch showing working section through deposit.

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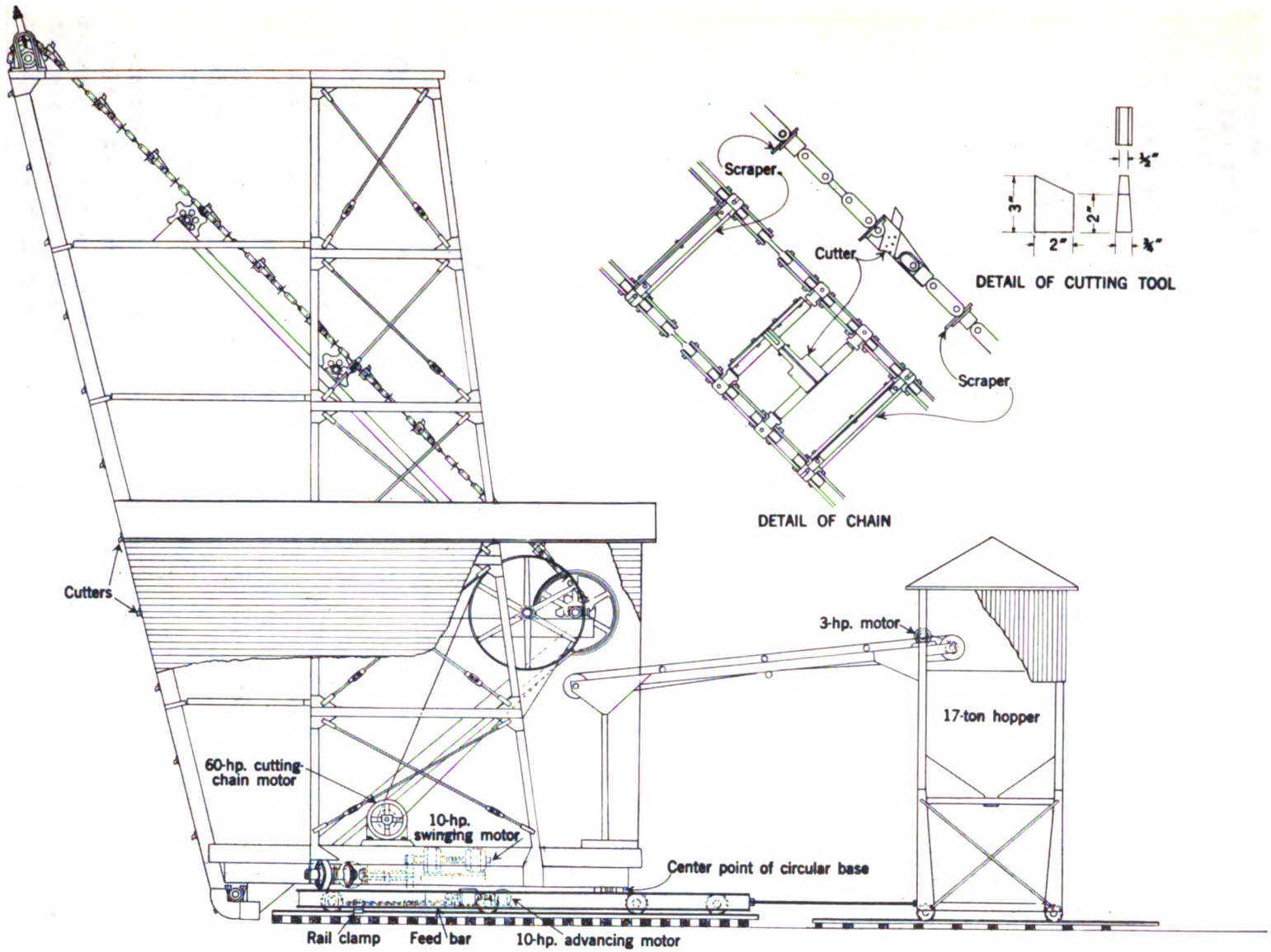

Figure 4.—Planer and hopper.

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Approximately 150 cubic yards of overburden are moved in an 8-hour shift. This is a relatively small mount, but it must be remembered that considerable time is required to clean the shale thoroughly. Approximately 2,400 cubic yards of shale are thus exposed, which is equivalent to 0.06 cubic yard of overburden to 1 of shale, or 16 cubic yards of shale exposed for every cubic yard of overburden removed.

The entire stripping operation requires only two men working part time - the shovel operator and a clean-up man, who looks after the conveyor, also, When not operating the shovel, the runner serves as a plant mechanic.

Mining

In recovering the shale from the exposed surface, an Eagle shale planer is used (fig. 4). This machine planes the shale from the full vertical face of the pit, gathers it, and conveys it onto a conveyor belt, which, in turn, deposits it in a steel hopper. The operation is entirely automatic and requires only one man to direct it.

The Eagle planer consists essentially of a steel tower mounted to swing radially on a heavy circular base 32 feet in diameter. This base, in turn, is mounted on 16 extra heavy, double-flanged, steel wheels 12 inches in diameter, rolling on five 60-pound rails. The rails are in 20-foot lengths and are spaced 6 feet 10 inches on centers. The steel tower carries two strands of forged and heat-treated steel chain, to which cutting tools are attached by means of cast-steel holders at approximately 2-foot intervals. This cutting-conveying chain is enclosed on three sides by steel housing along the cutting section or shale face. Its speed is 75 feet per minute. By means of the radial motion of the tower and the forward movement of the entire machine, the chain is forced against the shale. As the chain moves down the face the cutters plane the shale from the solid. The cut shale falls inside the steel enclosure to the floor of the pit, where it is picked up by scrapers on the same chain and discharged onto a 26-inch conveyor belt running to the planer hopper.

In addition to the radial movement on the circular base, the entire structure moves horizontally on the rails. In its swinging movement, each successive cutting edge falls approximately 2-1/2 inches to the right or left of the last cut, depending upon the direction of swing. It requires approximately eight minutes for the tower to make a complete cut over and back along the face, swinging through 180°. A 10-H.P. motor with enclosed speed reducer operates the swing mechanism.

In the forward movement into the face, the cutters remove 1/2 to 1 inch of shale. As the shale is very finely banded, it follows, from the previous paragraph, that the maximum size of the mined product will be 2-1/2 inches. Fines are such that approximately 20 percent is screened out and passes directly to the finished storage bin. It requires about 30 minutes to move the rail sections ahead. From the sketch of the planer (fig. 4), it will be

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noted that a 30-inch feed bar moves the entire unit forward. When this distance is covered, the machine is lifted by jacks and the rails are moved ahead; the feed bar is reset, and cutting is resumed. The entire base, having a 16-foot radius, will occupy 16 feet of the 20-foot rail sections, allowing the other 4 feet for advancing and safety. The machine will advance from 5 to 10 feet per day, depending upon the height of the face and the speed of the operation. A 10-H.P.motor with enclosed speed reducer controls the forward movement, and a 60-H.P.motor is required to drive the cutting-conveying chain.

The maximum cutting height of the machine is 50 feet. The cutting chain has a 12-1/2-percent slope. This will enable the planer to cut an inverted, conical face, having a diameter of 43 feet at the floor and 55 feet at the top.

In order to insure continuous operation of the planer, independent of the haulage system, a 17-ton movable steel hopper is placed directly behind the machine. This hopper is 10 feet long, 8 feet wide, and 9 feet deep. It is supported on four steel legs that are, in turn, mounted on four 12-inch-diameter, double-flanged, steel wheels that roll on 40-pound rails. These rails are also in 20-foot sections and the gage is 8 feet 2 inches (fig. 5). A roof is placed over this hopper in order that the cut shale can be kept dry at all times. The discharge gate of the hopper is approximately 7 feet above the haulage rails, so that the cars are run directly beneath it. The total height of the entire unit is approximately 25 feet. It is attached to the planer and moves forward with it.

The shale is delivered to this bin by means of a 26-inch conveyor belt inclined at about 15° with the horizontal, and moving at a speed of 60 feet per minute. It is driven by means of a 3-H.P.motor mounted on the steel frame supporting the conveyor.

The planer is required to cut up to 450 tons per 9-hour day when both plants are in full production. It requires only one manyto operate it, as stated before. A second man is used as a ground clean-up man.

Just what this means in the way of a very economical operation is better explained by Tefft in an article written by him in 1928:

> Before installing the planer, only one plant was operating, making an average of 80,000 bricks per day, using nine men to blast, load with an old type of steam shovel, haul, crush, and deliver to the dry-pan storage. At present no blasting and crushing are necessary. All the work of getting the shale to dry-pan storage is done by two men at the planer and one locomotive man.1/

It can readily be seen that the planer installation has effected material savings in unit cost per ton, not only in the mining operation but in the processing operation as well. In addition to this, it must be borne

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1/ Tefft, C. Forrest, The Development of the Shale Planer: Am. Ceram. Soc., vol. 11, no. 10, October 1928, p. 785.

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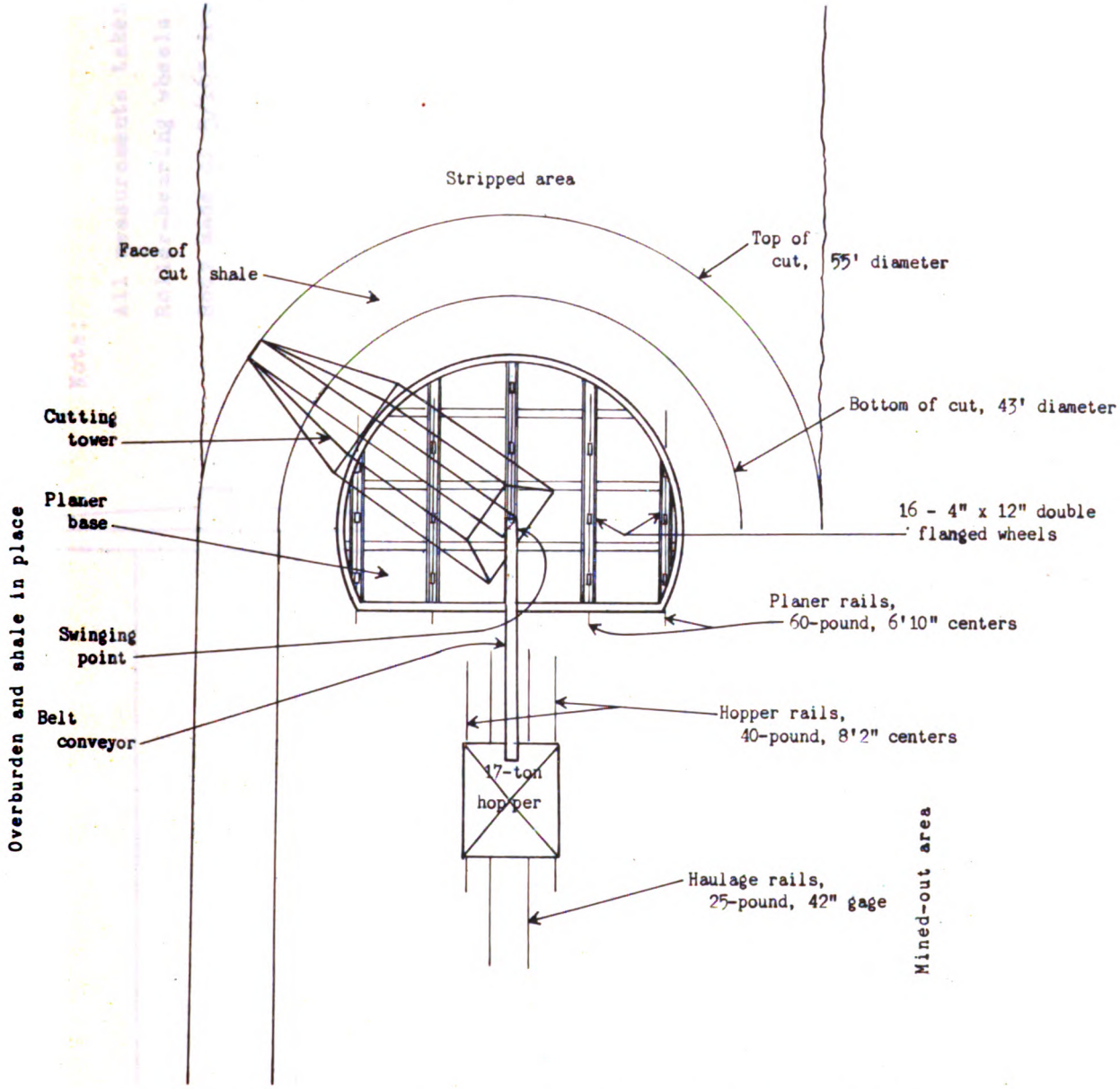

Figure 5.- Plan of planer-shale face and track lay-out, Claycraft Co.

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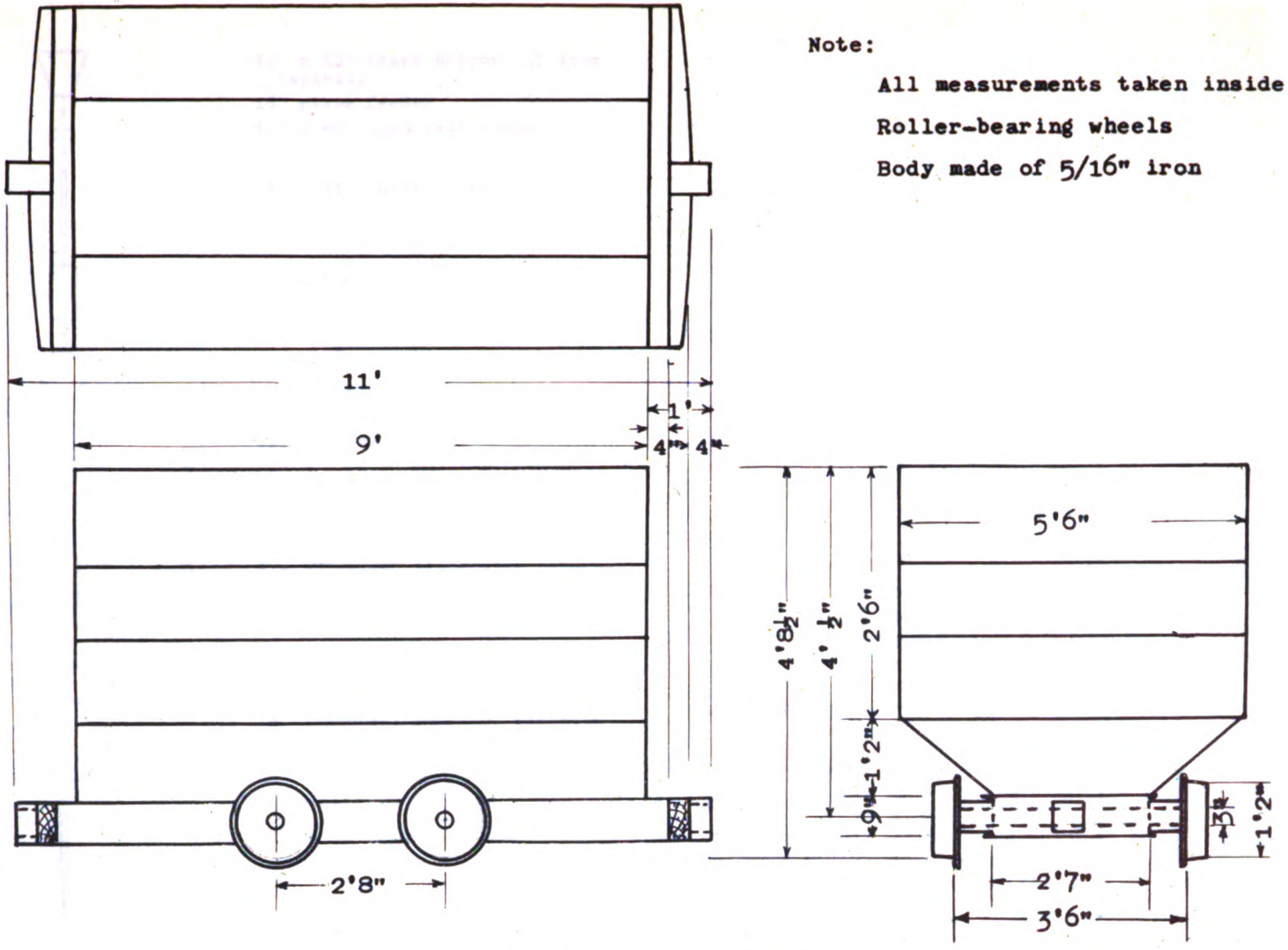

Figure 6.- Sketch of drop-bottom mine cars.

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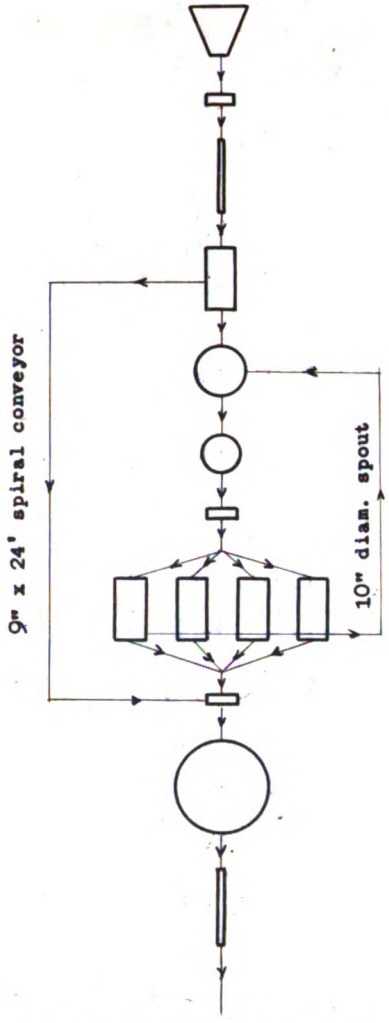

12' x 12' track hopper, 12 tons capacity
18" plate feeder
15" x 40' open-belt elevator

24" x 41' conveyor belt

1 - 40" x 96" piano-wire screen

8' diameter, 28-ton, circular steel bin
18" plate feeder
10' dry pan

18" x 43' enclosed-belt elevator

4 - 30" x 72" piano-wire screens

16" x 33' enclosed-belt elevator

14' diameter, 150-ton, circular steel bin
2 - 24" diameter, rotary disk feeders
18" x 33' conveyor belt

Figure 7.- Flow sheet of grinding, plant no. 4, Claycraft Co.

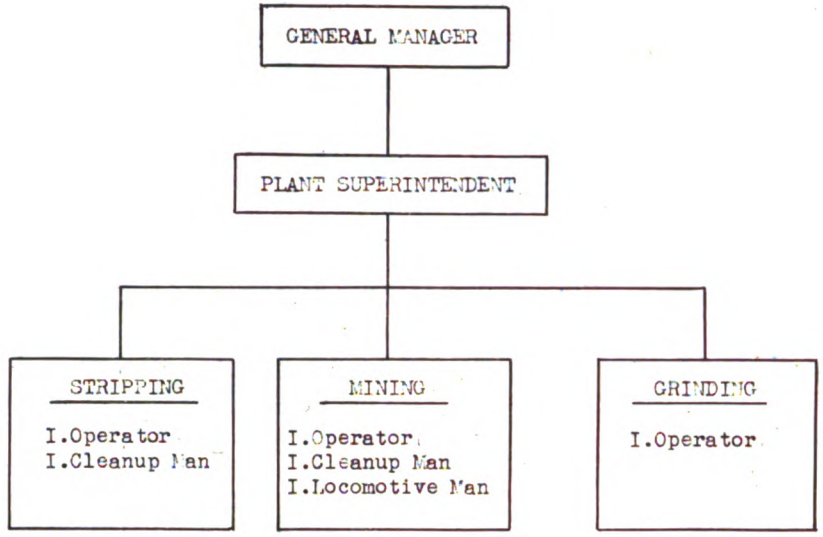

Figure 8.- Organization chart, Taylor Station, Claycraft Co.

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in mind that the planer gives a constant uniform mixture of the various shales, thus insuring a uniform firing shrinkage and color with corresponding smaller kiln losses. The ability of the planer to operate in all kinds of weather and the advantages of having the shale remain in its original state, rather than having it shot down to become soaked during wet weather, are also of great importance to smooth plant operation.

There are, no doubt, conditions under which the shale planer would not be practicable. The material must cut easily, the face must not weather and slough after being cut, and the nature and thickness of the deposit all are important factors to be considered. Its practicability in any type deposit must be determined carefully before hand.

Transportation

One 6-ton gasoline locomotive, 42-inch gage, is used to pull a train of two steel, drop-bottom, roller-bearing mine cars each of 7 tons capacity (fig. 6). The cars are pushed beneath the planer hopper and the locomotive man, from his cab, operates a lever arrangement located beside the track that connects with the bin gate. Thus, he can move the cars forward slowly and, at the same time, control the flow of shale into them. Plant no. 4 requires a haul of about 2,400 feet and Plant no. 5 about 5,000 feet per round trip. An adverse 6-percent grade about 500 feet in length must be negotiated before the ground elevation of the plants is reached. Upon arriving at the plant hopper, an automatic tripping device drops the bottom doors, the load is discharged, and, as the train moves forward, the doors are closed automatically for the return trip. In ordinary use, from 10 to 15 gallons of gasoline are consumed per day, or approximately 0.025 gallon per ton.

Drainage

The only water to combat is the normal rainfall. To the north is a small tributary of Big Walnut Creek (fig. 1). The floor of the pit is carried on a slight upward slope away from this stream. All rainfall is taken care of easily by this simple arrangement.

Grinding Plant

The shale from the open pit is dumped directly into a 12 by 12-foot steel track hopper of 12 tons capacity at Plant no. 4 (fig. 7). An 18-inch reciprocating plate feeder, driven by a 15-H.P.motor, moves the shale into an open 15-inch by 40-foot spaced bucket elevator. The buckets are 12 by 7-inches in size, spaced at 15-1/2 inches . The elevator has a capacity of 23 tons per hour at a speed of 290 feet per minute. The elevator is driven by a 7-1/2-H.P.motor with five V-belt drives on 30-inch centers.

The elevator discharges onto a 24-inch by 41-foot rubber conveyor belt, which transports the material across the railroad tracks into the top of the grinding building. This is driven by a 10-H.P.motor connected on 30-inch centers by six V-belt drives. It is inclined upward at about 15° with the

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horizontal, and has a capacity of about 88 tons per hour and a speed of 300 feet per minute. The material is discharged over a stationary piano-wire screen. This screen is 40 by 96 inches, has six 28-gage wires to the inch, making an 0.15-inch opening, and is inclined at 33° with the horizontal. Directly above the piano wires is a grid made of 5/8- by 1-1/2-inch bars set on edge. The function of this grid is to break the fall of the heavy material upon the piano wires. When a fine material is desired in the brick plant, a steel plate is placed over this grid, and thus everything bypasses the screen to the dry pan.

The material passing through this screen is conveyed by means of a 9-inch screw conveyor, 24 feet in length, having a capacity of 15 tons per hour and running at 80 R.P.M. to an elevator which will be described later, and then into the finished-product bin. The material passing over the screen falls into a circular steel bin 8 feet in diameter and of 28 tons capacity. From this bin an 18-inch reciprocating plate feeder moves the shale into a 10-foot dry pan for grinding.

The dry pan consists essentially of a large revolving pan placed between two heavy end frames. The pan is supported on and driven by a forged-steel vertical shaft. The bottom of the pan consists of bed plates which are placed in the path of two revolving rolls called mullers, 62 inches diameter, 16 inches face, and steel screen plates, which are placed outside the path of rotation of the mullers. The friction of the pan on the mullers causes them to rotate in a plane perpendicular to that of the plane of rotation of the pan. This machine travels 190 R.P.M. and is driven by means of a 75-H.P. 865-R.P.M. motor, connected with an eight V-belt drive on 8-foot centers.

The shale is fed into the pan whose rotation draws it under the mullers, where it is subjected to grinding action. When ground to sufficient fineness it passes through the screen plates and out of the pan into an enclosed 18-inch by 43-foot belt elevator.

This is a vertical-spaced-bucket elevator whose buckets are 14 by 8 inches, spaced 18 inches, capacity 25 tons per hour, and speed 314 feet per minute. It is driven by a sprocket and chain off a line shaft connected by a six V-belt drive to a 15-H.P. motor. The finely ground shale is then lifted to the top of the building, where it is discharged over four stationary piano-wire screens. These screens are 30 by 72 inches, made of 28-gage wire, spaced 6 to the inch, making an opening of 0.15 inch. They are placed at an angle of 50° with the horizontal. The coarse material is returned to the dry pan by gravity through a 10-inch diameter spout. The fine material is discharged into a 16-inch by 33-foot vertical belt elevator that lifts it to the finished storage bin. This is also of the spaced-bucket type, having buckets 12 by 7 inches, spaced 15-1/2 inches, a capacity of 23 tons per hour, and a speed of 296 feet per minute. The fines from the first screening operation also enter this elevator from the screw conveyor. This elevator is driven similarly to the above-mentioned elevator; that is, off the same line shaft by means of a sprocket and chain. The finished storage bin is 14 feet in diameter and has a capacity of 150 tons.

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Beneath this storage bin, two rotary disk feeders discharge the material onto an 18-inch by 33-foot rubber conveyor belt, inclined at about 25° where it is conveyed to the pug mill. The capacity of the belt is 43 tons per hour and its speed is 150 feet per minute. The conveyor, together with the pug mill, brick machine, etc., is driven from a counter shaft by a 125-H.P motor.

As stated before, the first screening operation passes 20 percent of the material directly to the finished-shale storage bin. Before this screen and the planer were installed, it was necessary to operate three 9-foot dry pans to handle full production. Thus, quite a saving was effected by this installation. The fact that the product of the planer is of such size as to require no primary crushing, makes this entire unit a very economical one.

Power

All power is purchased from the Columbus Railway, Power & Light Co. on a demand basis. It is stepped down from 23,000 to 440 volts and purchased on a sliding-scale basis that averages about 1-3/4 cents per kw.-hr.

EMPLOYEE PAY SYSTEM

The daily-wage system is in vogue here.

At present, 8 hours comprise a working day. At peak production a 9-hour day usually is worked. The pit operates approximately 300 days per year in normal times and produces an average of 410 tons per day.

A chart of the organization scheme is shown in figure 8.

SUMMARY OF COSTS

Total amount of material loaded during period 1927-28 (14 months):

Overburden ..... 21,700 cubic yards.
Shale ..... 170,430 tons.

Stripping Cost

Stripping formerly was contracted at $0.40 per cubic yard. Since the installation of the shovel and conveyor, the cost has averaged $0.07 per cubic yard.

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Costs per ton of Shale

	Cost per ton
Labor cost:	
Average tons per man-hour, 10.2.	
Mining (including stripping)	$0.09
Grinding	.03
Total labor cost	$0.12
Power cost:	
Planer and grinding (electric)	$0.0133
Shovel and locomotives (fuel)	.0175
Repair materials	.0375
Total power and supplies	$0.0683
Total operating cost	$0.1883

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